# MICRO LEAD FRAME PACKAGE AND METHOD TO MANUFACTURE THE MICRO LEAD FRAME PACKAGE

## Field of the Invention:

The present invention generally relates to the field of micro lead frame design packaging and assembly. More specifically, the present invention comprises a micro lead frame substrate that is adapted to receive at least one semiconductor die and multiple discrete passive components which may be mounted within a lead frame or directly onto a circuit board.

## Background of the Invention:

Today's multi chip modules (MCM's) in power applications face significant challenges in terms of heat dissipation and heat management. Coupled with the need to dissipate heat in a uniform manner with low thermal impedance, there is also a need to reduce space and cost. Traditional approaches to packaging MCM's have been in the form of a Land Grid Array (LGA) or Ball Grid Array (BGA) type substrate, which consist of multiple chips (semiconductor dice) plus passive components placed on a laminate substrate. The substrate material conventionally has a high-thermal impedance and, even with enhanced via technology for heat management, still falls short of the low thermal impedance of a lead frame design.

A conventional lead frame device has excellent thermal conductance and optimum heat dissipation with regard to the power component mounting surfaces. But, a conventional lead frame design and manufacturing process limits its ability to have multiple passive components mounted within the package. Manufacturing a lead frame that is adapted to receive a power semiconductor die and passive components is often associated with long manufacturing times, increased expenses, and is generally not considered an efficient manufacturing option. Conventional lead frames are adapted to receive only power semiconductor dice. Thus, external components must be coupled to the lead frame to ensure operational effectiveness, which also adds to both the cost (of procurement, placement, etc.) and the space of the customer's board.

Figs. 1A–1B illustrate a conventional lead frame package **10**. The lead frame includes a semiconductor die pad **14** and multiple leads **16** arranged about the periphery of the lead frame **10**. A conventional method for producing the leadless semiconductor chip package shown in Figs. 1A–1B comprises the steps of: (1) attaching a semiconductor chip **12** onto the die pad **14** of a lead frame **10**, wherein the lead frame **10** comprises a plurality of leads **16** arranged about the periphery of the die pad **14**; (2) wire-bonding the leads of the lead frame **10** to bonding pads on the semiconductor chip (shown as wires **18** in Fig. 1b); and (3) forming a package body **20** over the semiconductor chip **12** and the lead frame **10** in a manner that each lead **16** of the lead frame **10** has at least a portion **17** exposed from the bottom of the package body. This conventional lead frame package **10** only supports a single semiconductor chip **12**. The package **10** cannot support any passive components. Thus, the passive components (*e.g.*, resistors and capacitors) are necessarily external to the package **10**.

<u>Summary of the Invention</u>:

The proposed invention resolves many of these issues by providing a lead frame substrate that is adapted to receive discrete passive components and may be placed within a micro lead frame package or directly onto a circuit board, and further providing a method of manufacturing the lead frame.

An aspect of the present invention is to provide a lead frame package that is relatively low in cost, has a relatively simple construction, and integrates a power semiconductor die and passive components within the package. In one embodiment, a micro lead frame substrate ("MLF substrate") that includes a semiconductor die pad electrically coupled to multiple termination pads is mounted on a lead frame. The semiconductor die pad is adapted to receive a power semiconductor die (e.g., a MOSFET), a controller ASIC, a PWM controller, or the like. The termination pads are adapted to receive discrete passive components (*e.g.*, resistors and capacitors) or a bonding wire. All of the semiconductor components are therefore located within the same package.

Another aspect of the present invention is to provide a package in which the MLF substrate may be configured to meet the specific package requirements. In one embodiment, the termination pads within the MLF substrate are linked together by a combination of temporary and permanent connection bars. The temporary connection bars provide rigidity

to the MLF substrate and are eventually removed. The temporary connection bars do not provide an electrical connection between termination pads in the final lead frame package. The permanent connection bars electrically couple the semiconductor die pads and the termination pads together.

Yet, another aspect of the present invention is to provide a MLF substrate for a semiconductor package. In one embodiment, the lead frame includes a housing with a center pad and leads around its periphery. The MLF substrate mounts on the center pad of the lead frame and is electrically coupled to the leads. Thus, the lead frame package includes discrete passive components and saves customer board space. In another embodiment, the MLF substrate is mounted directly onto the customer board, so that heat generated by a power semiconductor die is dissipated directly into the customer board. In yet another embodiment, only the semiconductor die pads and the leads of the MLF substrate contact the customer board. The bottom surface of the MLF substrate has a stepped feature whereby the contact pads (*e.g.*, power semiconductor die pads, controller pads, and leads) are thicker than the non-contact portions of the MLF substrate (*e.g.*, permanent connection bars).

Still another aspect of the present invention is to provide a method for manufacturing a lead frame package that includes power semiconductor dice and multiple passive components. In one embodiment, the MLF substrate is stamped out of a single piece of material. Alternatively, the MLF substrate may be formed by an etching or laser manufacturing process. A molding compound is applied to the MLF substrate to support the semiconductor die and termination pads. The temporary connection bars are preferably removed before the semiconductor components are mounted on the MLF substrate. In another embodiment, the temporary connection bars are removed after the semiconductor components are mounted on the MLF substrate. The semiconductor components are mounted onto the MLF substrate by a surface mount technology.

Another aspect of the present invention is to manufacture a lead frame package using the MLF substrate above, including the steps of applying a molding compound over the MLF substrate to provide support for the termination pads, the semiconductor die pads, the temporary connection bars, and the permanent connection bars. Once the molding compound has been applied, the temporary connection bars may be removed. Each power semiconductor die is mounted to a semiconductor die pad and the passive components are

mounted across specific termination pads. After the semiconductor components are mounted and the termination pads and semiconductor dice are wire bonded to leads, a mold material is applied to the MLF substrate to encapsulate the semiconductor components and bonding wires.

## Brief Description of the Drawings:

FIGS. 1A-1B illustrate a conventional lead frame, according to the prior art;

FIG. 2 is a plan view of an embodiment of the MLF substrate, according to the present invention;

FIG. 3 is a partial plan view of the MLF substrate shown in FIG. 2,

FIG. 4 is a partial plan view of the MLF substrate shown in FIG. 2, illustrating the a molding compound material applied to the MLF substrate;

FIG. 5 is a plan view of the MLF substrate shown in FIG. 4, illustrating the MLF substrate after the temporary connection bars have been removed;

FIG. 6 is a plan view of the MLF substrate shown in FIG. 5, illustrating several discrete passive components mounted on the MLF substrate;

FIG. 7 is a plan view of an embodiment of a lead frame package incorporating the MLF substrate;

FIG. 8A-8C illustrate a second embodiment of the MLF substrate, according to the present invention; and

FIGS. 9A-9B illustrate a third embodiment of the MLF substrate, according to the present invention.

## Detailed Description of the Invention:

Several embodiments of the present invention will now be described with reference to Figs. 2-9. In general, the present invention provides an MLF substrate that allows power semiconductor components, as well as passive components, to be mounted within the same

package. The invention can be applied to, but is not limited to, providing optimum thermal performance within a package that requires multiple or single silicon die combined with single or multiple passive components. The invention may replace existing micro lead frame products that require external passives by placing the external components within the package, and thus reducing space and cost.

Fig. 2 illustrates a lead frame template **100** according to one embodiment of the present invention. The lead frame template **100** is preferably manufactured from a single sheet of thermally and electrically conductive material **101**. Copper (Cu), a Cu-based alloy, iron-nickel (Fe--Ni), a Fe--Ni-based ally, or the like is preferably used as the material for the lead frame template **101**. It is within the scope and spirit of the present invention for the lead frame template **100** to comprise other materials. The single sheet of material **101** preferably has a surface material finish appropriate for soldering or applying other electrically and thermally conductive adhesion materials (*e.g.*, conductive epoxy).

In this embodiment, four MLF substrates **102** have been formed into the single sheet of material **101**. The lead frame template **100** may include more than or fewer than four MLF substrates **102**. By way of example only, each MLF substrate **102** may be created through a stamping, etching, milling or laser manufacturing process. Each MLF substrate **102** is preferably attached to the single sheet of material **101** by more than one temporary connection bar **104**. The temporary connection bars **104** secure the MLF substrate **102** in place with respect to the single sheet of material **101**. As will be described later, the temporary connection bars **104** are eventually removed from each MLF substrate **102** and are not intended to provide an electrical connection between the semiconductor components in the final package.

The configuration of each MLF substrate **102** may vary. The number of semiconductor components that will be mounted on an MLF substrate **102** is dictated by the design requirements of the semiconductor package. Fig. 2 illustrates one embodiment of a MLF substrate **102**. In this embodiment, the MLF substrate **102** includes semiconductor die pads **106a, 106b, 106c**, termination pads **108**, temporary connection bars **104**, and permanent connection bars **110**. The termination pads **108** shown in Fig. 2 are substantially rectangular in shape. It is within the scope and spirit of the invention for the termination pads **108** to comprise other shapes, such as, but no limited to oval, square, or circular.

In general, the design or layout of each MLF substrate **102** may be predetermined to meet the specific electrical requirements of the semiconductor package. For example, if each MLF substrate **102** is stamped out of the sheet of material **101**, the stamping die may be configured to produce the exact number of semiconductor die pads **106** and termination pads **108** required for the semiconductor package. A strip of the material **101** is left between each MLF substrate **102** so that multiple MLF substrates **102** may be transported by a single sheet.

The termination pads **108** form a pattern or matrix within the MLF substrate **102**. As discussed above, the pattern or matrix of termination pads **108** may vary greatly. The termination pads **108** generally provide two functions: (1) to provide a mounting surface for passive components (*e.g.*, resistors **R1**, **R2**, **R3**, **R4** shown in Fig. 6); and (2) to provide a mounting surface for bonding wires **240**. Regardless of the pattern, the termination pads **108** are linked together by at least one temporary connection bar **104** and/or at least one permanent connection bar **110**. A termination pad **108** may be linked to an adjacent termination pad **108** by more than one temporary connection bar **104** and/or more than one permanent connection bar **110**. Initially, the temporary connection bars **104** and the permanent connection bars **110** provide rigidity to the MLF substrate **102**.

Fig. 3 illustrates the connections between termination pads **108** in more detail. In general, adjacent termination pads **108** may be linked together in one of two ways: (1) the adjacent termination pads **108** are linked by a temporary connection bar **104** (e.g., termination pads **108a** and **108g**); or (2) the adjacent termination pads **108** are linked by a permanent connection bar **110** (e.g., termination pads **108g** and **108h**). More than one temporary connection bar **104** and/or permanent connection bar **110** may extend from a termination pad **108**.

The portion of the MLF substrate **102** shown in Fig. 3 includes twelve termination pads **108a-108l**. The connections between several of the termination pads **108** will now be described to provide examples of how the termination pads **108** may be linked together. The termination pad **108a** has four temporary connection bars **104** and one permanent connection bar **110** extending from it. One temporary connection bar **104** links the termination pad **108a** with the termination pad **108b**. A second temporary connection bar **104** links the termination pad **108a** to the termination pad **108g**. The third and fourth temporary connection bars **104** link the termination pad **108a** to a permanent connection bar **110** that is adjacent to the

termination pad **108a**. The permanent connection bar **110** links the termination pad **108a** with the termination pad **108i**. The four temporary connection bars **104** fix the termination pad **108a** in place with respect to the surrounding elements of the MLF substrate **102** (*e.g.*, termination pads **108**, **108g**) and create an electrical connection between the same elements.

The termination pad **108f** illustrates that a termination pad **108** may be linked by fewer connection bars. The termination pad **108f** is linked to the termination pad **108e** by a permanent connection bar **110** and is linked to the termination pad **108l** by a temporary connection bar **104**. The permanent connection bar **110** and temporary connection bar **104** fix the termination pad **108e** in place. In general, adjacent termination pads **108** are connected together by a single connection bar. It is within the scope and spirit of the present invention to link adjacent termination pads together by more than one connection bar.

Adjacent termination pads **108** may be linked together by all temporary connection bars **104** or all permanent connection bars **110**. For example, the termination pad **108l** is linked to adjacent termination pads by four temporary connection bars **104**. Alternatively, the termination pad **108e** is linked to adjacent termination pads only by permanent connection bars **110**. Each temporary connection bar **104** is shown as having a different shape than the permanent connection bars **110** simply to illustrate which connection bars are temporary and which connection bars are permanent. It is within the spirit and scope of the present invention for the temporary and permanent connection bars **104**, **110** to have the same shape or have a shape other than that shown in Fig. 3.

Fig. 4 illustrates a molding compound **112** applied to the MLF substrate **102**. The molding compound **112** fixes each components within the MLF substrate **102** (*e.g.*, termination pads **108**, semiconductor die pads **106**, and connection bars **104**, **110**) in the molding compound **112**. In a preferred embodiment, the molding compound **112** fills in the empty spaces or gaps throughout the MLF substrate **102**. The gaps in the MLF substrate **102** are defined by the areas in which a semiconductor die pad **106**, a termination pad **108**, or the connection bars **104**, **110** are not located within the MLF substrate **102**. The molding compound **112** provides additional rigidity to the MLF substrate **102** in addition to the permanent connection bars **110** and the temporary connection bars **104**. The molding compound **112** is preferably an epoxy-resin or another electrically insulating material.

The molding compound **112**, when applied to the MLF substrate **102**, preferably does not cover the top or bottom surface of the semiconductor die pads **106** or the termination pads **108**, since they provide mounting surfaces for the semiconductor dice and passive components. The molding compound **112** is therefore preferably thinner than the sheet of material **101**. If the molding compound **112** initially covers a semiconductor die pad **106** or a termination pad **108**, the surface of the pad may be milled or etched to remove the molding compound **112**. In a preferred embodiment, the temporary connection bars **104** and permanent connection bars **110** are not covered by the molding compound **112** either. However, it is within the spirit and scope of the present invention to cover the temporary and permanent connection bars **104**, **110** with the molding compound **112**.

Fig. 5 illustrates that the temporary connection bars **104** are preferably removed from the MLF substrate **102**, after the molding compound **112** has been applied. Thus, the components of the MLF substrate **102** (*e.g.*, the termination pads **108**, the permanent connection bars **110**, and semiconductor die pads **106**) are held in place primarily by the molding compound **112**. As shown in Fig. 5, a termination pad **108**, if linked to an adjacent termination pad **108** at all, is linked only by a permanent connection bar **110**. The remaining permanent connection bar **110** provides an electrical connection between the linked termination pads **108**. For example, the termination pad **108a** initially had four temporary connection bars **104** and one permanent connection bar **110** extending from it when the MLF substrate **102** was initially formed (see Figs. 2-3). Once the temporary connection bars **104** are removed, the termination pad **108a** is only linked to the termination pad **108i** by a single permanent connection bar **110**.

The temporary connection bars **104** may be removed at later stages of the manufacturing process. The temporary connection bars **104** simply must be removed prior to electrical testing of the package. Otherwise, the temporary connection bars **104** will provide unwanted electrical connections between termination pads **108**. In an alternative embodiment, the temporary connection bars **104** are removed through a back etching process after the semiconductor components are mounted on the MLF substrate **102** (discussed later).

An adhesive tape (not shown), preferably made of epoxy resin, polyamide resin, polyester resin or the like, may be attached to the bottom surface of the MLF substrate **102** to further stabilize the MLF substrate **102**. Adhesive tape is known to persons skilled in the art

and does not require further disclosure. If an adhesive tape is applied to the MLF substrate **102**, it is preferably applied to the MLF substrate **102** prior to mounting the semiconductor components on the MLF substrate **102**.

After the tape is applied to the bottom surface (see Fig. 8B) of the MLF substrate **102**, the semiconductor elements are mounted to the top side (see Fig. 8B) of the MLF substrate **102**. There are many methods known within the art for mounting semiconductor components within a package. By way of example only, the MLF substrate **102** may be screen-printed with a solder paste in a pattern that corresponds to the pattern of the passive components that will be mounted on the termination pads **108**. Each passive component is then positioned on a corresponding pair of termination pads **108** and the solder is reflowed using conventional surface mount technology. Alternatively, the mounting surfaces of the passive components may be printed with solder paste and then mounted on the pair of termination pads **108**. Other methods for mounting semiconductor components are known within the art and do not require further disclosure.

Fig. 6 illustrates one embodiment of the MLF substrate **102** with passive components disposed between several of the termination pads **108**. In this embodiment, the resistors **R1**, **R2**, **R3**, **R4** are disposed between several of the termination pads **108**. Each resistor is electrically connected by its leads on a termination pad **108**. For example, the resistor **R1** is connected by its lead **E1** to the termination pad **108a** and is connected to the termination pad **108g** by its lead **E2**. Similarly, the resistor **R2** is connected by its lead **E1** to the termination pad **108h** and is connected to the termination pad **108i** by its lead **E2**.

As previously discussed, the termination pads **108a** and **108i** and the termination pads **108g** and **108h** are each electrically coupled together by a permanent connection bar **110**. The resistor **R1** electrically couples the termination pads **108a** and **108g** together. The resistor **R2** electrically couples the termination pads **108h** and **108i** together. The resistors **R1** and **R2** are thus electrically coupled together. The resistors **R3** and **R4** are similarly electrically coupled together.

In this embodiment, passive components are not mounted on the termination pads **108b**, **108c**, **108f**, **108l**. Thus, the termination pads **108b**, **108c**, **108f**, **108l** provide mounting surfaces for bonding wires. Bonding wires **240**, such as a gold wires, are connected between

each termination pad **108b**, **108c**, **108f**, and **108l** and an external lead **232** (*see* Fig. 7) of the semiconductor package **200** using a conventional wire-bonding process.

Each semiconductor die pad **106** is adapted to receive a power semiconductor die **210** (*e.g.*, a MOSFET or a controller device **212** (*e.g.*, a PWM controller, a controller ASIC, etc.). The power semiconductor dice **210** and controller devices **212** may be mounted on each semiconductor die pad **106** prior to or after the passive components (*e.g.*, **R1**-**R4**) are mounted on the MLF substrate **102**. As shown in Fig. 7, the MLF substrate **102** includes two power semiconductor dice **210** – one mounted on the semiconductor die pad **106b** and one mounted on the semiconductor die pad **106c**. A controller device **212** is mounted on the semiconductor die pad **106a**. Each power semiconductor die **210** includes bonding pads (not shown). Bonding wires **240** electrically connect the bonding pads of the power semiconductor die **210** to the leads **232** of the lead frame **230**. The embodiment shown in Fig. 7 is merely illustrative. The configuration of the semiconductor package **200** may vary according to the performance requirements of the package.

The top surface of the MLF substrate **102** is sealed with a molding material after the passive components, the power semiconductor dice **210**, and the controller devices **212** are mounted on the MLF substrate **102** and the wire bonding is complete. After the molding material is cured, the adhesive tape is removed from the bottom surface of the MLF substrate **102**.

As previously discussed, the temporary connection bars **104** do not have to be removed from the MLF substrate **102** immediately after the molding compound **112** is applied to the MLF substrate **102**. The temporary connection bars **104** may remain within the MLF substrate **102** through all of the manufacturing steps discussed above. In an alternative embodiment, the temporary connection bars **104** are removed after the adhesive tape is removed from the MLF substrate **102**. A back etching process is performed after the tape is removed to remove the temporary connection bars **104** from the MLF substrate **102**. The back etching process creates holes in the molding material **112** where the temporary connection bars **104** were removed. The holes are preferably filled in by applying additional molding compound to the back side of the MLF substrate **102**.

Fig. 7 illustrates a lead frame package **200** that incorporates the MLF substrate **102.** The lead frame package **200** includes a housing **230** that has leads **232** about its periphery. The sheet of material **101** is eventually divided into single units – each unit including a single MLF substrate **102**. This process is commonly known within the industry as singulation. Each unit is then mounted on the housing **230**. The lead frame package **200** is preferably encapsulated in a package body in a manner such that the bottom surface of each lead **232** has at least a portion exposed from the bottom of the package body for making an external electrical connection. The molding material has been removed to illustrate the interior of the lead frame package **200**.

The lead frame package **200** shown in Fig. 7 comprises two power semiconductor dice **210**. Each semiconductor die **210** may be attached to the semiconductor die pad **106** by an adhesive such as silver paste and the silver paste is cured after die attach. The active surface of each semiconductor die **210** includes a plurality of bonding pads (not shown). Each bonding pad is electrically connected to a lead **232** by a bonding wire **240**. The termination pads **108** that do not have a passive component mounted to it provide a mounting surface for the bond wires **240**. Several of the termination pads **108** are shown as electrically connected to a lead **232** by a bonding wire **240**. The configuration of the lead frame package **200** shown in Fig. 7 may vary and is not intended to limit the scope of the present invention. The package **200** includes power semiconductor components and passive components may then be mounted onto the customer's circuit board.

Figs. 8A-8C illustrate yet another embodiment of an MLF substrate. In this embodiment, the MLF substrate **302** mounts directly onto the customer's circuit board. The configuration of the MLF substrate **302** is substantially similar to the MLF substrate **102** shown previously in Figs. 2-6. Components within the MLF substrate **302** that are similar to the MLF substrate **102** (*e.g.*, termination pads **108**, permanent connection bars **110**, etc.) retain the same reference numeral.

The MLF substrate **302** comprises a unitary construction from the sheet of material **301** similar to the MLF substrate **102**. Regardless of the manufacturing process, each MLF substrate **302** shown in Fig. 8A includes an outer frame **304** that connects the MLF substrate **302** to the single sheet of material **301** (*see* Fig. 9A). The outer frame **304** comprises permanent leads **303** and temporary leads **305**. The temporary leads **305** fix the MLF

substrate **302** and similar to the temporary connection bars **104**, are eventually removed from the MLF substrate **302** before the MLF substrate **302** is electrically tested. The temporary connection bars **104** and the temporary leads **305** may be removed simultaneously or at different stages of the manufacturing process. As shown in Fig. 8A and 8C, the semiconductor dice **210** and the termination pads **108** electrically couple directly to the permanent leads **303** via at least one bonding wire **240**.

Removing the temporary leads **305** from the MLF substrate **302**, in effect, transforms the MLF substrate **302** into a leadless package (*see* Fig. 8C). The MLF substrate **302** may therefore mount directly on the customer's circuit board. As previously discussed above, the molding material **112** fills in the gaps of the MLF substrate and does not cover the bottom surface of the semiconductor dies pads **106** or the bottom surface of the terminations pads **108**. In this embodiment, the MLF substrate **302** has a substantially uniform thickness, shown as **h** in Fig. 8B. Thus, the entire bottom surface **310** of MLF substrate **302** contacts the circuit board. One advantage of the MLF substrate **302** is that the heat dissipated from each power semiconductor die **210** is transferred directly from its bottom surface, through the semiconductor die pad **106**, and onto the customer's circuit board – providing low thermal resistance. A drawback, however, is that the non-conductive portions of the MLF substrate **302** (*e.g.,* molding compound **112**) also contact the circuit board. A conventional practice within the industry is to run tracks or traces along the top surface of the circuit board, which, in this embodiment, is located under the MLF substrate **302**. The entire bottom surface **310** of the MLF substrate **302** contacts the circuit board, when the MLF substrate is mounted on the circuit board with no space between the bottom surface **310** of the MLF substrate **302** and the top surface of the circuit board, a customer cannot run traces along the top surface of the circuit board.

Figs. 9A-9B illustrate still another embodiment of the MLF substrate **302**. In this embodiment, the bottom surface **310** of the MLF substrate **310** has a stepped feature to allow a customer to run traces along the top surface of the circuit board. Fig. 9A illustrates four MLF substrates **302** formed into a single sheet of material **301**. The lead frame template **300** may include more than or fewer than four MLF substrates **302**. By way of example only, each MLF substrate **302** may be created through a stamping, etching, milling or laser manufacturing process.

Regardless of the manufacturing process, each MLF substrate **302** shown in Fig. 9A is connected to the single sheet of material **301** by the permanent leads **303** and the temporary leads **305**. In contrast to the MLF substrate **302** shown in Figs. 8A-8C, the MLF substrate shown in Fig. 9B has a stepped feature on the bottom or contact surface **312**. In this embodiment, only the pads that are required to operate the package (*e.g.*, permanent leads **303** and semiconductor die pads **106**) contact the circuit board when the MLF substrate **302** is mounted on the circuit board. The stepped feature of the MLF substrate **302** is preferably formed when the MLF substrate **302** is initially created. As shown in Fig. 9B, the bottom surface **312** of the MLF substrate **302** provides the semiconductor die pads **106** permanent leads **103** that extends out further than the molding material **112**. When the MLF substrate **302** is mounted on the circuit board, gaps **314**, are created between leads **303**, that traces can be run between. The gaps **314** also provide advantages to cleaning the circuit board. For example, the raised bottom surface of the MLF substrate **302** allows cleaning of the circuit board with standard cleaning equipment while minimizing the potential for trapping water, flux, etc. under the MLF substrate **302**, which will lead to electro migration and the like.

The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to precise forms disclosed. Obviously, many modifications and variations will be apparent to practitioners skilled in the art. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiment and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalents.